Two Advanced Automatic Dependent Surveillance - Broadcast (ADS-B) Applications Within the FAA Safe Flight 21 Program

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ICNS 2004 Conference

April 28, 2004

Overview

- Safe Flight 21 (SF-21)
- Two ADS-B Advanced Concepts
  - Surveillance Services and Cockpit Display of Traffic Information (CDTI) Assisted Visual Separation (CAVS)
    - Background
    - Purpose
    - Concept Description
    - Infrastructure Requirements
    - Maturity
- Closing Remarks

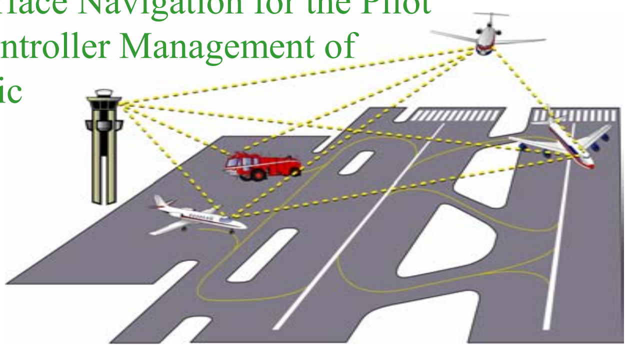
Safe Flight 21 (SF-21) Program Overview

- Expedite emerging technology
- Government and industry cooperation
- Demonstrate nine enhancements in test beds: Alaska, Louisville, Memphis…
- Examine requirements / risks, build a little, test a little, deploy a little (transition to national airspace)

Ground-to-Ground

• Improved Surface Navigation for the Pilot

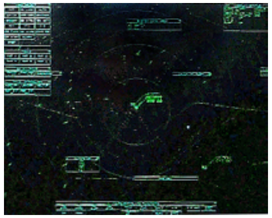
• Enhanced Controller Management of Surface Traffic

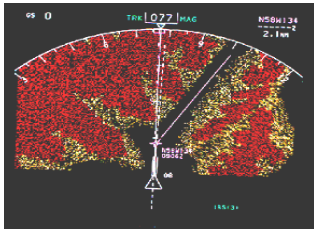


Air-to-Ground & Self-Contained

• Affordable Reduction of Controlled Flight into Terrain (CFIT)

• Surveillance Coverage in Non-Radar Airspace





Air-to-Air

• Improved Separation Standards

• Improved Low-Visibility Approaches

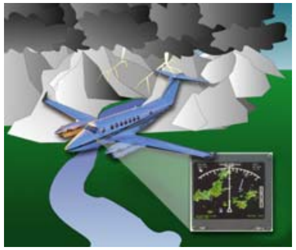
• Enhanced See and Avoid

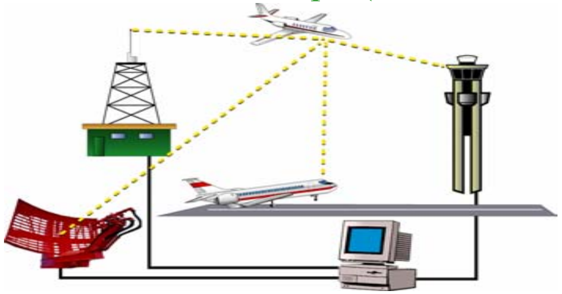
• Enhanced Operations for En Route Air-to-Air

Current Focus

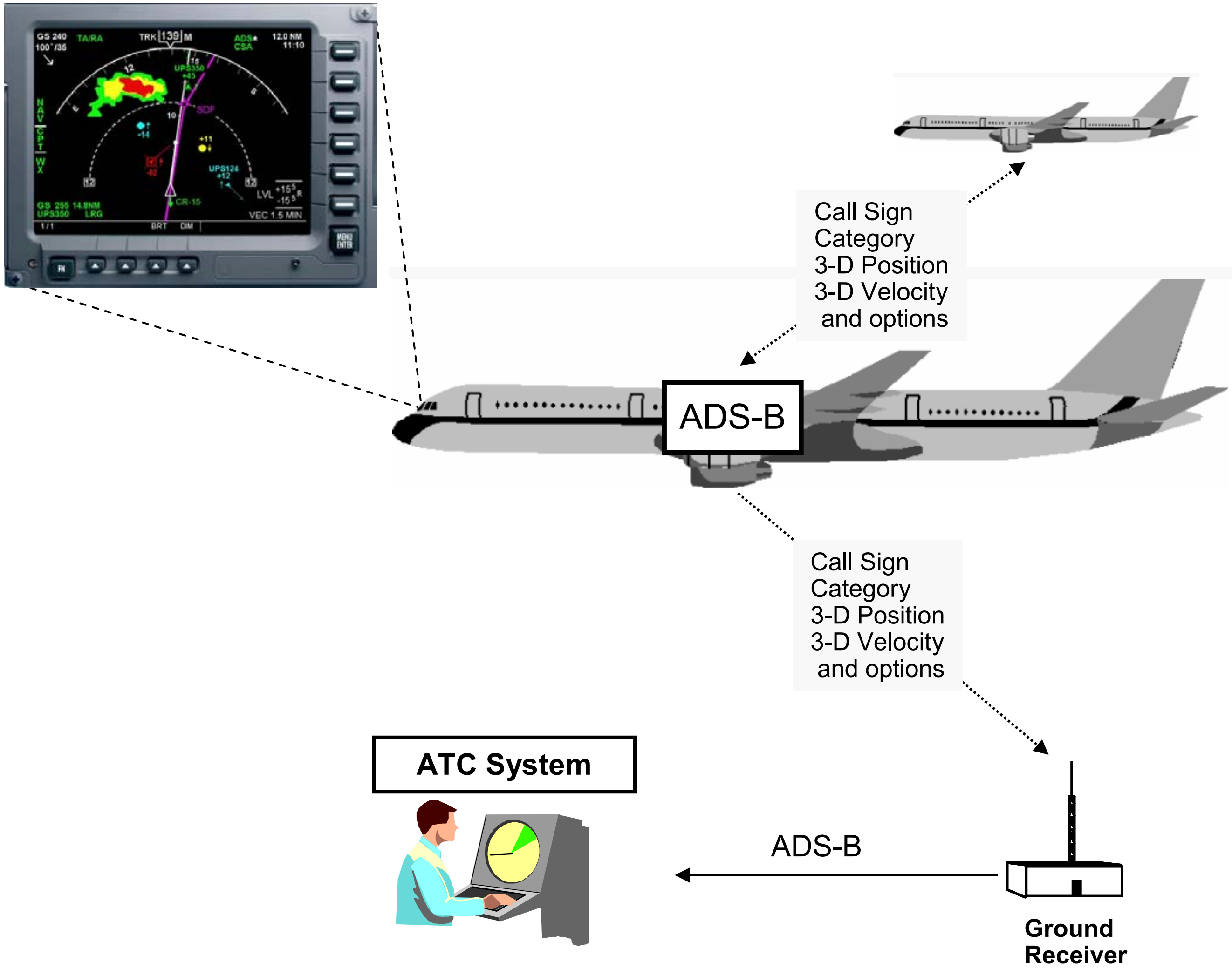
Ground-to-Air

• Weather and Other Data to the Cockpit (FIS-B & TIS-B)





ADS-B



Call Sign
Category
3-D Position
3-D Velocity
and options
ADS-B
Call Sign
Category
3-D Position
3-D Velocity
and options
ATC System
ADS-B
Ground Receiver

SF-21 Locations & Objectives

- Ohio River Valley - Cargo Airline Association (CAA)
  - United Parcel Service and Federal Express
  - Increased hub throughput and improved efficiency/safety
    - Surface management
    - Terminal operations
    - ADS-B / Air Traffic Control (ATC) Automation interfaces

- Alaska Capstone / FAA Alaska Region
  - Reduce accident rates for General Aviation / Air Taxi
    - Poor weather
    - Controlled Flight Into Terrain
    - Mid-air collisions
  - Improve search and rescue
  - Provide highly integrated cockpit and ATC services

- Gulf of Mexico
  - Surveillance in non-radar areas
    - Helicopter operators
    - Commercial airlines

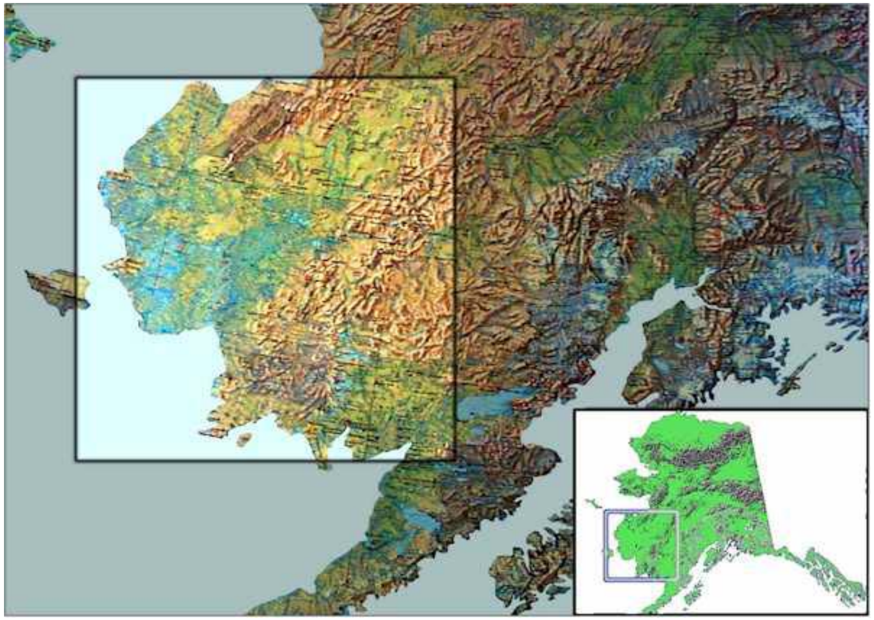
Surveillance Services / Radar-Like Services using ADS-B

Background

- Radar surveillance capability accounts for significant operational efficiency, safety, and improved services
  - E.g., overcomes “one-in-one-out” procedures – only one Instrument Flight Rules (IFR) aircraft at a time is allowed to enter the non-radar airspace
- Not all airspace is under radar surveillance coverage
  - Subject to line-of-sight and shadowing effects
  - Coverage does not exist down to surface in all areas
  - Terrain or cost constraints limit the deployment of radars in many areas
- Radar surveillance capability makes it possible to offer a wide range of services to Visual Flight Rules and IFR aircraft
  - Smaller separation minima
  - Flight following and traffic advisories
  - Minimum safe altitude warning
  - Navigational assistance
  - Search-and-rescue activities
- However, it is not cost-effective to site and install ground-based radar systems to achieve complete radar coverage

Purpose

- Provide cost-effective radar-like services where not currently available
- In Alaska…
  - Bethel is the “hub” for 50+ villages
  - Region is nearly 100% dependent upon aviation
  - High accident rate
  - No surveillance radar coverage below ~5000 ft
  - Intended to require no increase in controller and pilot workload



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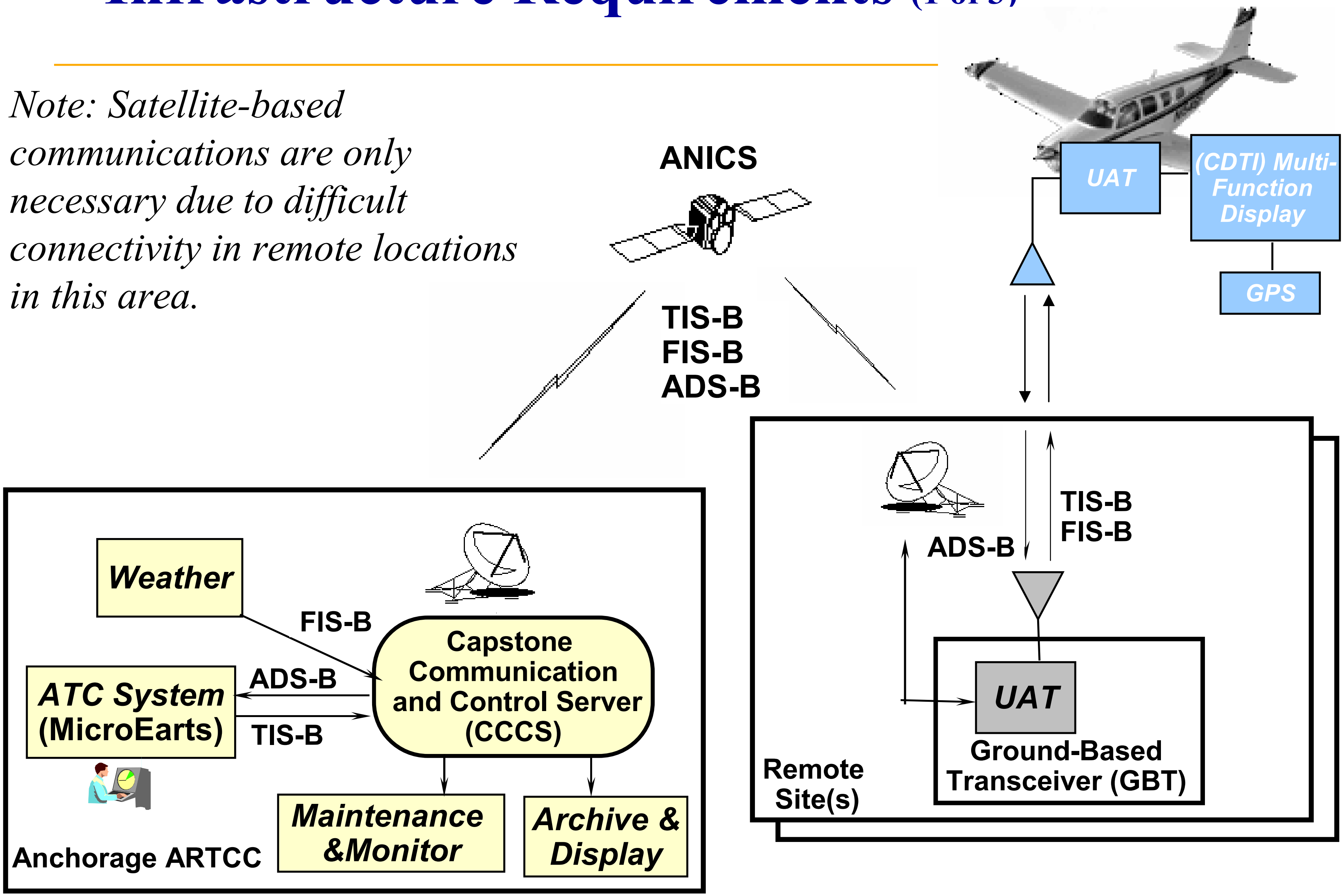
Concept Description

- ADS-B to provide the controller with position and other information on ADS-B-equipped aircraft on a surveillance display
  - Depiction of ADS-B-derived information on the ATC display similar to radar
- Network of strategically placed ground-based listening stations
- Same services and procedures should be used for both ADS-B-derived and conventional radar data
- In Alaska…
  - ADS-B can be used as a source for aircraft position beyond or below radar coverage or when primary and / or secondary radar surveillance systems are unusable or unavailable
  - ADS-B is a tertiary form of surveillance, with raw radar remaining primary and beacon system remaining secondary
    - Controllers requesting ADS-B now to be primary (controllers have developed confidence in the ADS-B data)
  - Phraseology for transfer of radar identification (i.e., “handoff,” “radar contact,” “point out,” and “traffic” apply)

Infrastructure Requirements (1 of 3)

Note: Satellite-based communications are only necessary due to difficult connectivity in remote locations in this area.



ANICS = Alaskan NAS Interfacility Communications System

Infrastructure Requirements (2 of 3)
GBT

UPS Aviation Technologies SM
A subsidiary of United Parcel Service

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Infrastructure Requirements (3 of 3) – Avionics

Universal Access Transceiver (UAT)

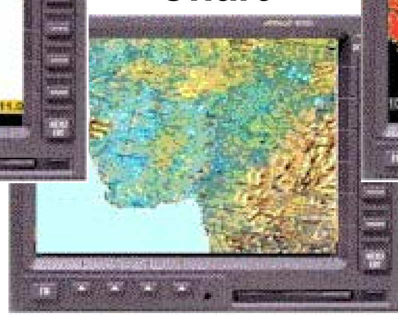
GPS Receiver

Multi-function Display

VFR Sectional Chart

Graphical Weather

IFR En route Chart



Terrain Avoidance

Textual Weather

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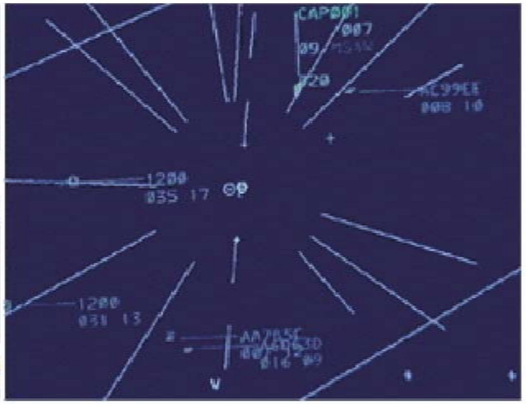
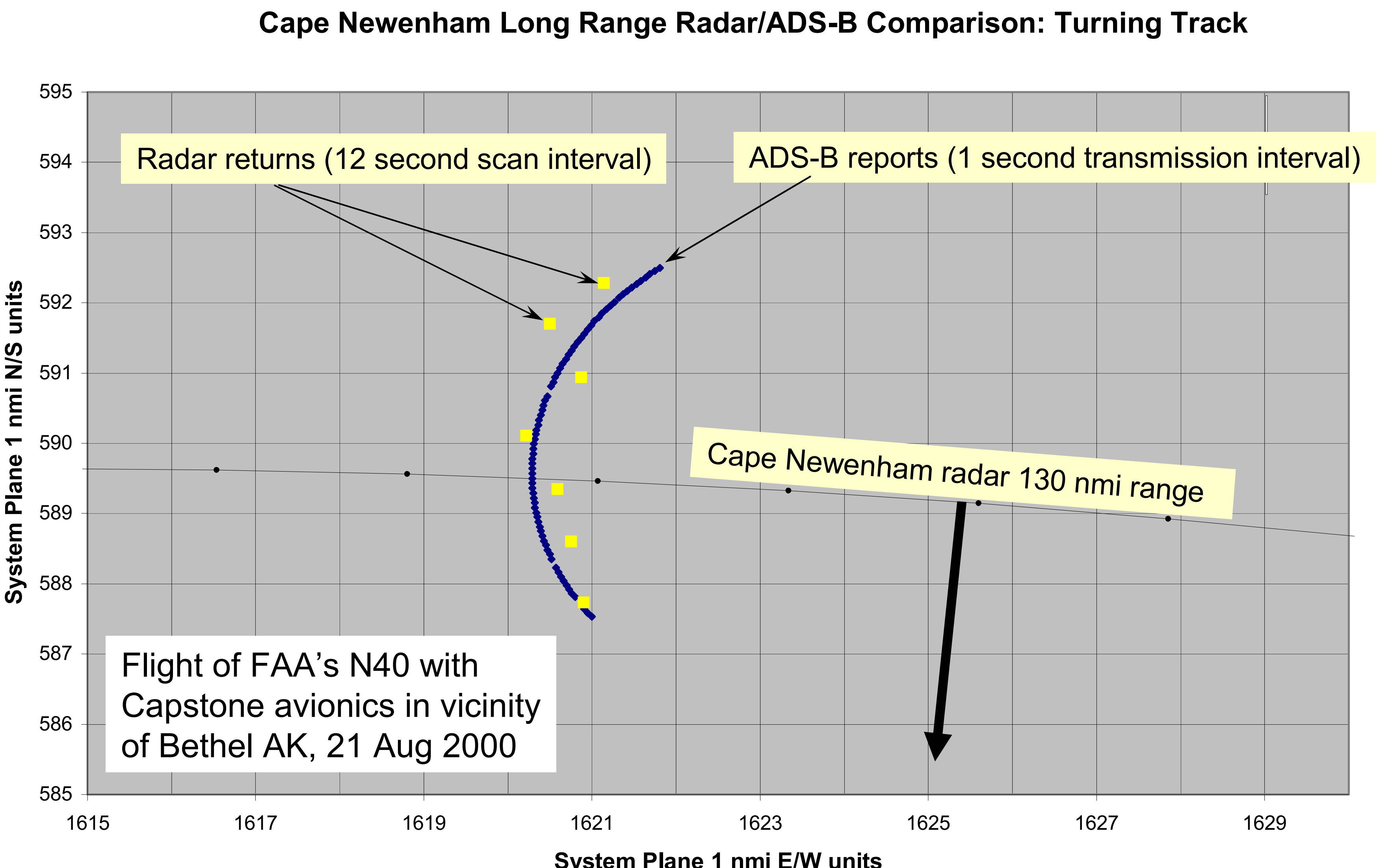
Maturity



- In Alaska…
  - Total of 11 ADS-B operational ground stations in service
    - Three provide ADS-B information to Anchorage Center for IFR ATC services
    - Eight more provide uplink-only services
      - 160,000 square miles receiving uplink services
      - These eight to provide ADS-B information to ARTCC for IFR services soon
  - Radar-like ATC services since January 1, 2001
  - 200+ aircraft equipped to date
    - 1,000,000+ flight hours on the airborne equipment
- Planning for expansion to Southeast Alaska and remainder of US
- Concept being implemented by Australia
- International standards being developed

Radar Versus ADS-B



Cockpit Display of Traffic Information (CDTI) Assisted Visual Separation (CAVS) during Visual Approach

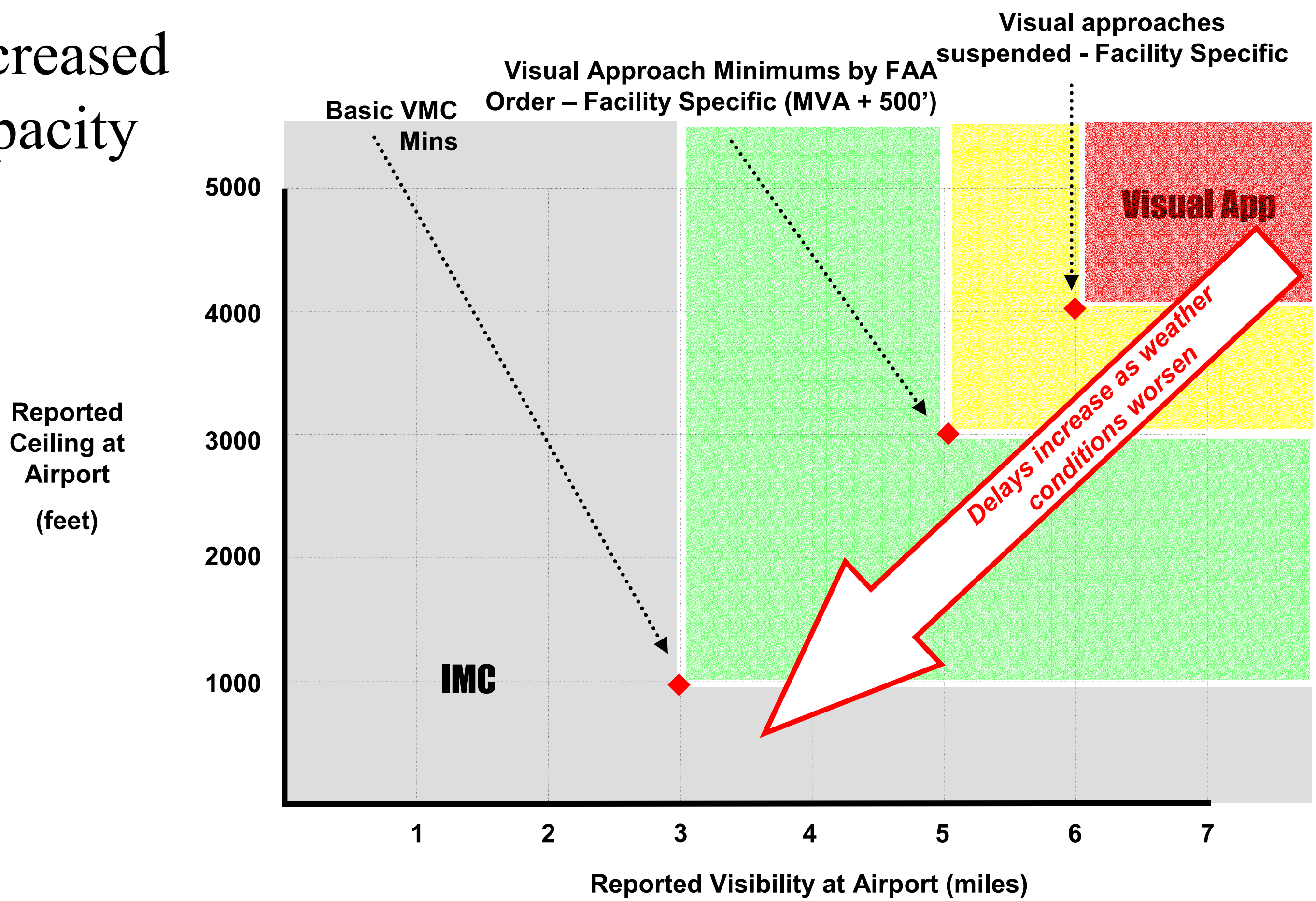
(formerly CEFR)

Background – Visual Separation

- Visual separation can be applied by ATC to separate aircraft by a pilot who sees the other aircraft involved
- Traffic advisories are issued by ATC to the pilot who must search for the traffic, acquire the traffic, and accept responsibility for maintaining separation from that aircraft
- Pilot acceptance of visual separation includes:
  - Maintaining constant visual surveillance;
  - Maneuvering the aircraft as necessary to avoid the other aircraft or to maintain in-trail separation;
  - Avoiding wake;
  - Not passing the other aircraft until it is no longer a factor ; and
  - Promptly notifying ATC if visual contact with the other aircraft is lost
- Pilot acceptance of visual separation relieves the controller of separation responsibility for that particular aircraft and allows for more flexible operations

Purpose (1 of 3)

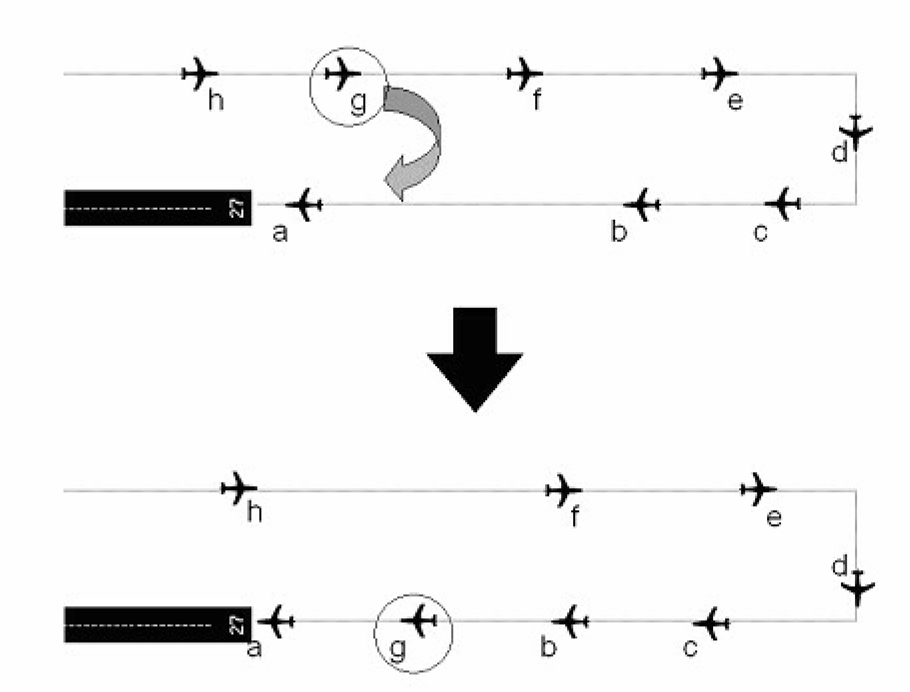
Increased capacity



Initial CAVS Potential Benefit

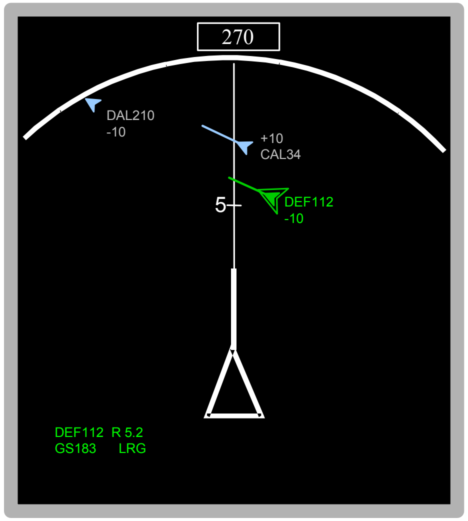
Purpose (2 of 3)

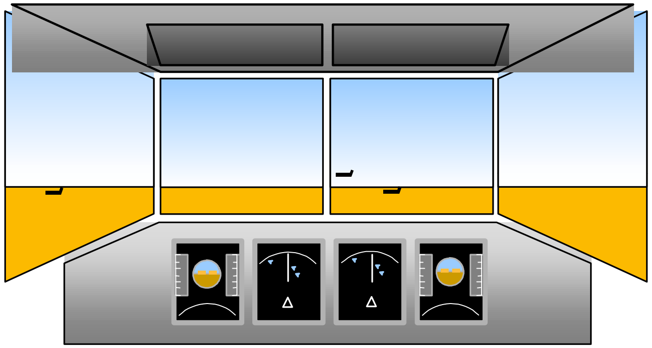
Controller flexibility



Purpose (3 of 3)

Increased pilot traffic awareness when conducting visual approaches in marginal conditions





Concept Description (1 of 5)

- What?
  - Visual separation including the CDTI (i.e., CDTI is authorized for use in lieu of visual out-the-window contact)
  - No other operational changes to current visual approach procedures

- Where?
  - Terminal Area - Class B or C airspace

- Why?
  - To increase capacity under deteriorated weather conditions when visual approaches are suspended

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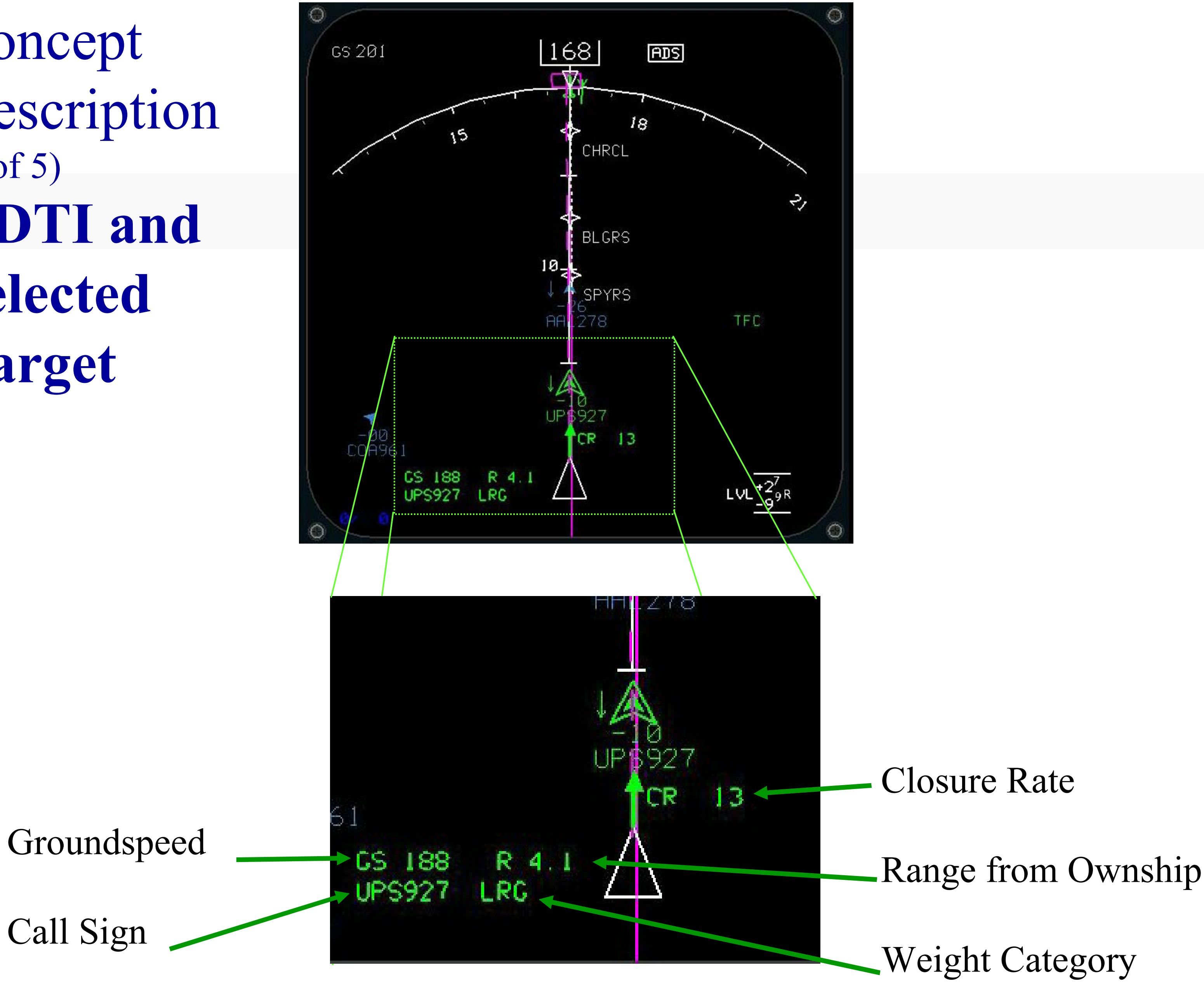
Concept Description
(2 of 5)

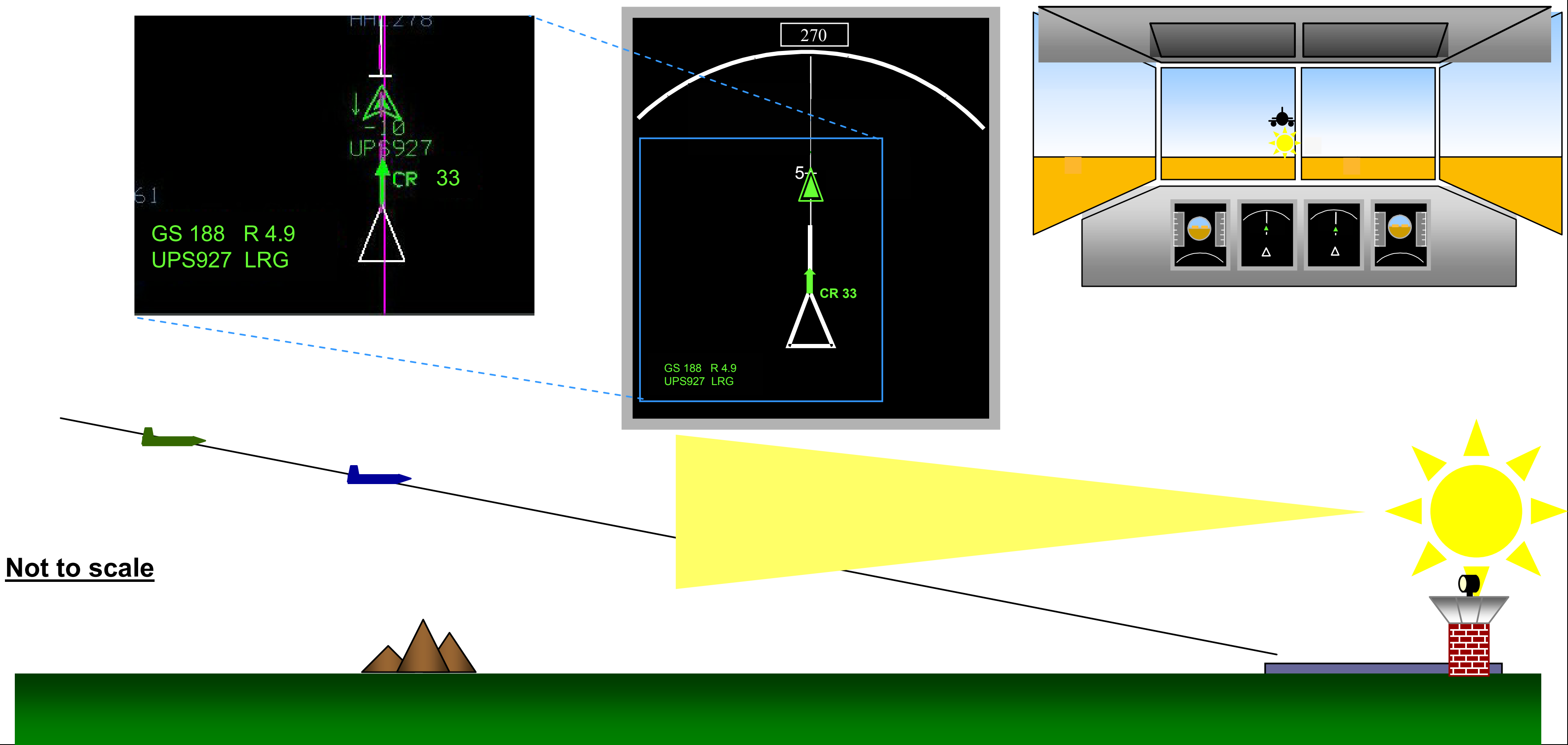
CDTI and Selected Target



Concept Description (3 of 5)

Visual Approach CAVS Example - *Set-Up*

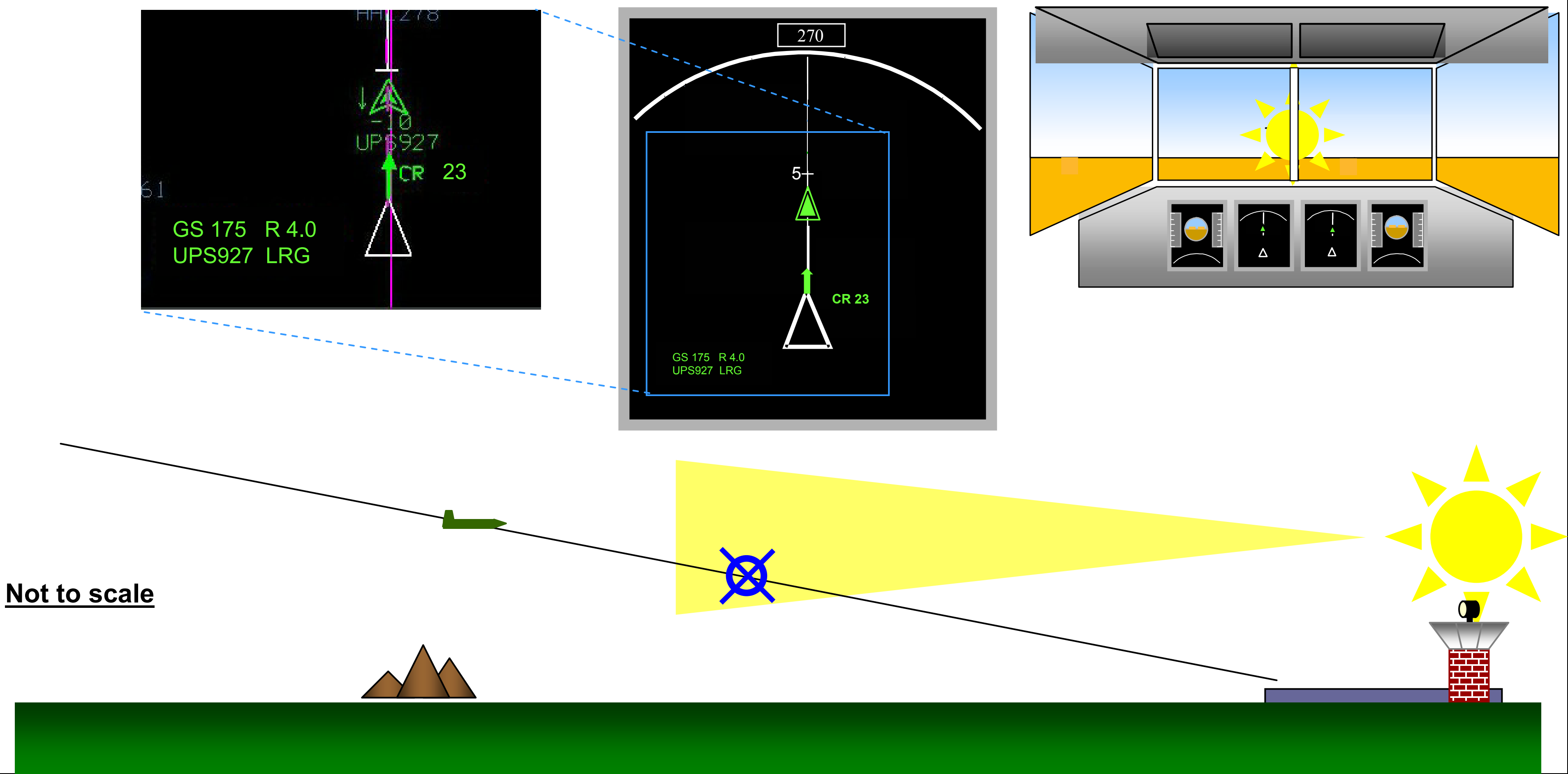
- Controller provides traffic advisory
- Pilot initial out-the-window acquisition and correlation with CDTI
- Pilot target selection on the CDTI
- Controller clearance to maintain visual separation and / or visual approach



Concept Description (4 of 5)

Visual Approach CAVS Example - *CDTI for Separation*

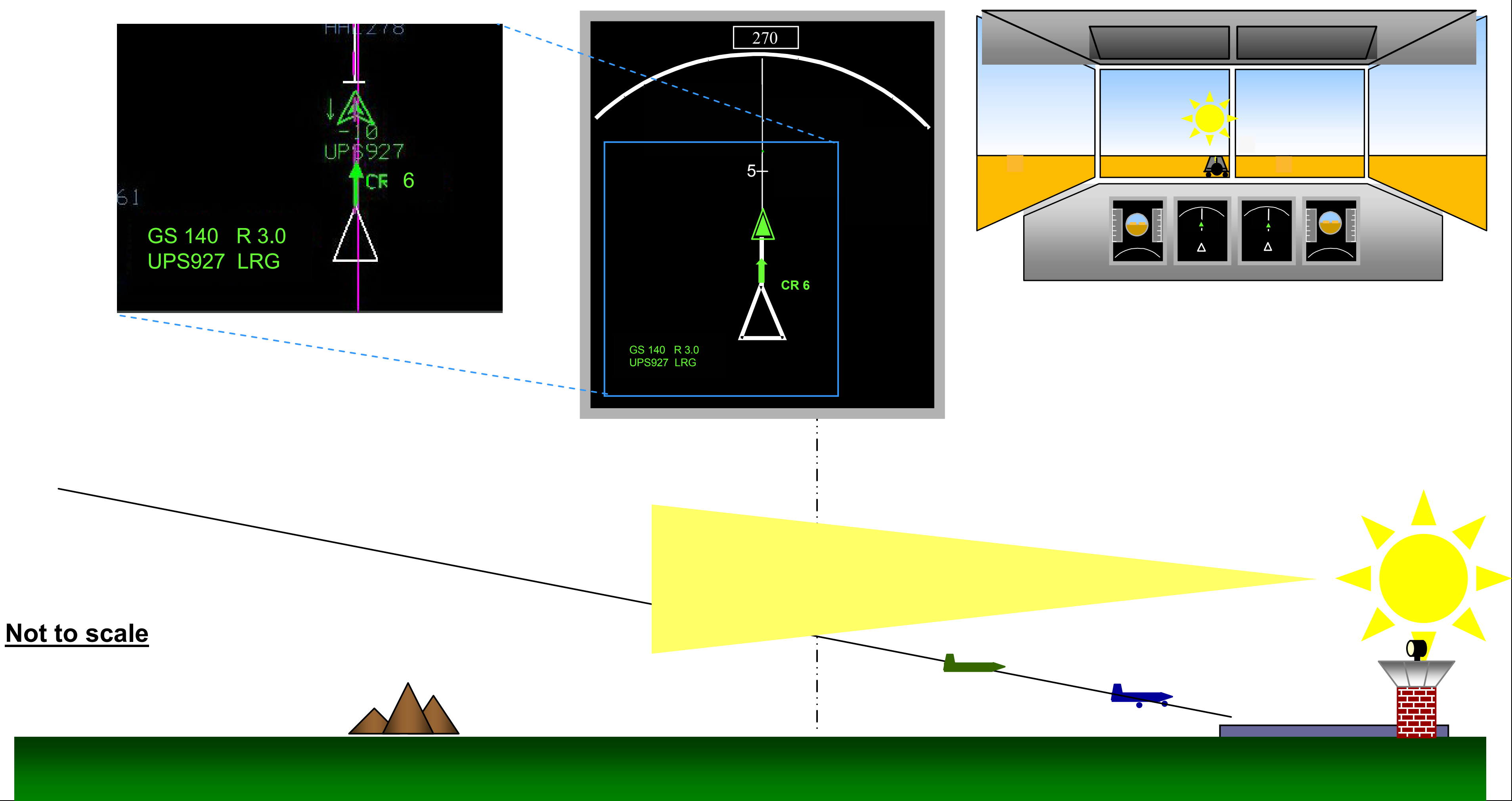
- Once lead aircraft is lost out-the-window, CDTI only is used for separation (CAVS concept)



Concept Description (5 of 5)

Visual Approach CAVS Example - *Landing*

- Continue to normal landing using both visual and / or CDTI



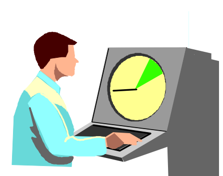
Infrastructure Requirements

Flight Deck

GARMIN
World Leader in Navigation and Communication

ATC

Method of identifying capable aircraft



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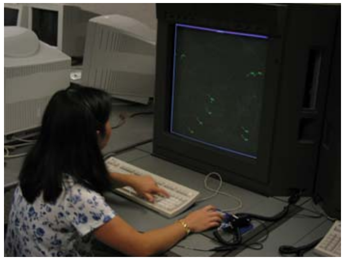
Maturity (1 of 5)

- 2002
  - Initial application description
  - Initial business case
  - MITRE simulations
  - Call sign procedure approved
  - Formal decision to continue research
- 2003
  - Updated business case
  - MITRE simulations
  - Formal decision to continue research
  - Initial operational safety assessment
- 2004
  - Operational approval planned to be sought by UPS

Maturity (2 of 5)
Overview of Four MITRE Simulations

- Participants
  - 56 Pilots
  - ~10 Air Traffic Controllers
- Simulation Environment
  - Medium fidelity, twin jet aircraft
    - CDTI (Primary field of view & throttle quadrant)
  - Other traffic: large, 757, heavy
  - Terminal ATC display
  - Louisville, Kentucky (SDF)



- Procedure
  - **Conditions**: Day and night; Instrument and visual approaches
  - **Independent Variables**: Cloud thicknesses, spacing assignment, CDTI size and location, throttle control / workload, spacing alert, failure condition, 2 crew member operations
  - **Data**: Subjective- pilot and controller acceptability, displays, workload, call sign procedures; Objective- pilot spacing performance

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Maturity (3 of 5)
Results of Four MITRE Simulations

- CEFR concept / separation based on a CDTI is viable from a pilot (N=56) perspective based on feedback on the following topics:
  - General difficulty of the procedure
  - CDTI use for spacing and separation
  - Safety
  - Workload (about the same as current visual approaches)
  - Head down time
  - Comparison to current operations (day and night visual approaches)
- Time on CDTI for separation not an issue
- ATC continues to play key role

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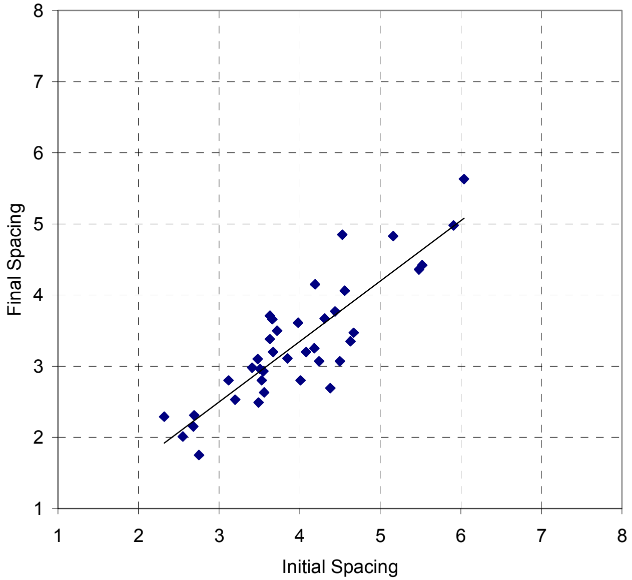
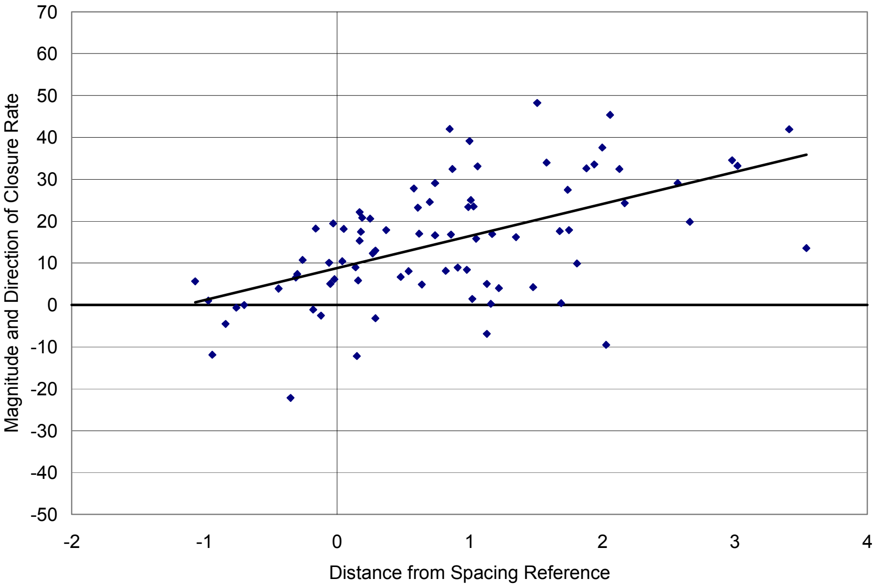
Maturity (4 of 5)
Results of Final MITRE Simulation



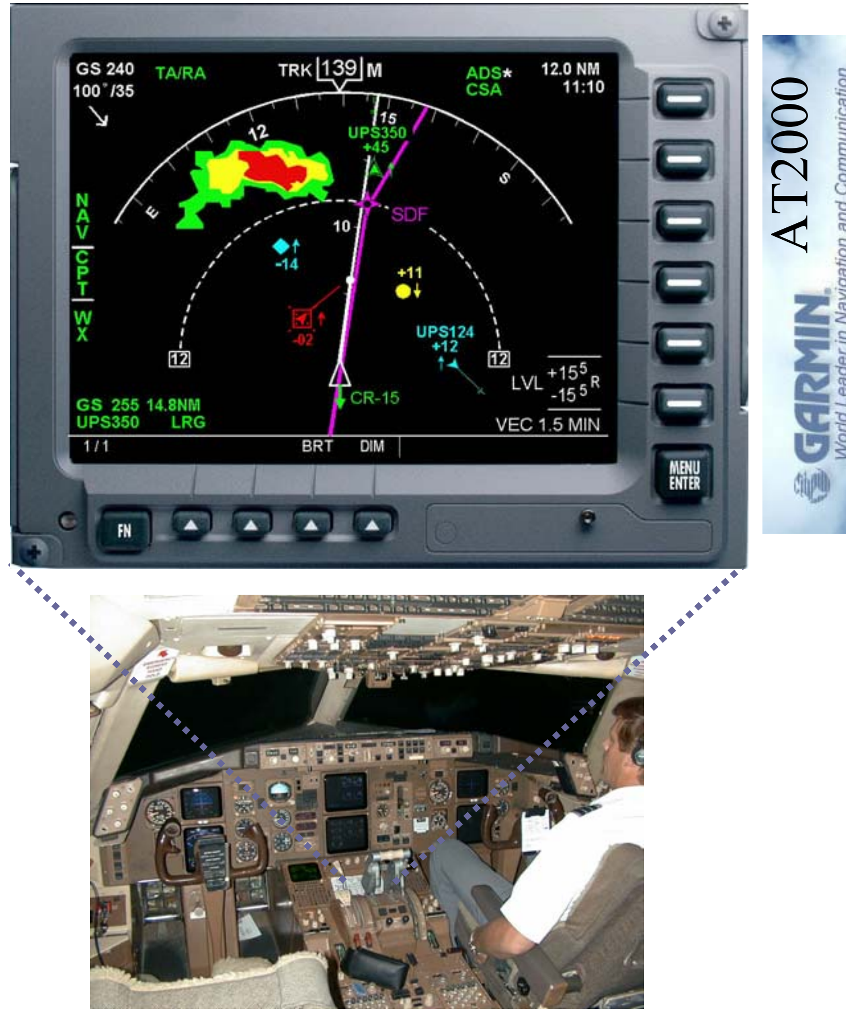


- Relationship between initial spacing and spacing at the threshold when following large aircraft
- Conclusion: As initial separation decreased the threshold spacing decreased

- Relationship between derived distance from spacing reference and mean closure rate across the entire approach
- Conclusion: CDTI used for higher closure rates when spacing between aircraft was greater. Lower closure rates when spacing between aircraft was reduced

Maturity (5 of 5)

- UPS equipping with AT2000 CDTI and conducting enhanced situational awareness with 757 / 767 fleet (total of 107 aircraft)
  - Includes conflict detection, situational awareness, and see and avoid
- Metrics being collected and measured against baseline
- Next steps:
  - Implement call sign use in traffic advisory procedure
  - UPS plans to seek approval for CEFR in late 2004



Closing Remarks

- Development process for Surveillance Services and CAVS
  - User and approver involvement throughout development
  - Attempted to remain as close to current procedures as possible

Safe Flight 21 Activity Status

- Over past four years ADS-B foundation put in place
  - Avionics & Standards…Ground Infrastructure…Automation
- Service Portfolio
  - Radar-like services…Enhanced Situational Awareness…Surface Management…FIS-B…TIS-B
- Interest in other "pockets" to solve specific needs / services